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Abstract:
This report describes the Human System Interface (HSI) analysis, design and test activities that will be performed to support the development of requirements and design guidelines to facilitate the incorporation of High Altitude Long Endurance (HALE) Remotely Operated Aircraft (ROA) at or above FL400 in the National Airspace System (NAS). These activities are required to support the design and development of safe, effective and reliable ROA operator and ATC interfaces. This plan focuses on the activities to be completed for Step 1 of the ACCESS 5 program. Updates to this document will be made for each of the four ACCESS 5 program steps.

Status:

Document Status SEIT-Approved

Limitations on use:
"This document is an interim deliverable. It represents the Human Systems Integration Program Plan (HSIPP) limited to enroute operations above FL430. Operations below FL430 and terminal operations have not been addressed in this document." The HSIPP describes the Human Engineering Tasks that were to be completed in Step 1 of the ACCESS 5 program.

ACCESS 5 - STEP 1
HUMAN SYSTEM INTEGRATION PROGRAM PLAN (HSIPP)

FEBRUARY, 2005

This report describes the Human System Interface (HSI) analysis, design and test activities that will be performed to support the development of requirements and design guidelines to facilitate the incorporation of High Altitude Long Endurance (HALE) Remotely Operated Aircraft (ROA) at or above FL400 in the National Airspace System (NAS). These activities are required to support the design and development of safe, effective and reliable ROA operator and ATC interfaces. This plan focuses on the activities to be completed for Step 1 of the ACCESS 5 program. Updates to this document will be made for each of the four ACCESS 5 program steps.

The following document was prepared by a collaborative team through the noted work package. This was a funded effort under the Access 5 Project.

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1 INTRODUCTION

1.1 OVERVIEW

This plan describes the Human System Integration (HSI) activities that will be performed to support the development of requirements and design guidelines to establish certification guidelines/requirements for High Altitude Long Endurance (HALE) Remotely Operated Aircraft (ROA) to fly at or above FL400 in the National Airspace (NAS). The intent is to provide file and fly access to the NAS for HALE ROAs, identically to that provided to manned aircraft. This plan focuses on the tasks to be completed for Step 1 of the ACCESS 5 program. Updated plans for Steps 2 through 4 will be developed prior to the commencement of each step.

The ACCESS 5 HSI IPT will perform applicable MIL-HDBK-46855B analyses, design support and test activities to support requirements development and to establish HALE Air Vehicle Control Station (AVCS) functional requirements and design guidelines. In addition, specific procedures and design guidelines will be developed in support of the Simulation IPT so it may develop a generic AVCS for test and evaluation. Furthermore, the task will evaluate the impact of ROA operations on the air traffic control system. **Activities performed in Step 1 will not address HSI requirements for ROA maintenance personnel. These requirements may be addressed in subsequent steps of this effort.**

Major activities to be accomplished in Step 1 will include:

a. **Literature Review** - Reviewing applicable FAA standards, FARs, FAA Order 7110.65P, and guidance provided in the Aeronautical Information Manual, etc. to support the development of AVCS design requirements, and pilot/operator knowledge skill, and ability (KSAs) requirements; and the impact of ROAs on air traffic control.

b. **ROA and ROA Pilot Analyses** - Performing analyses to determine pilot functional requirements, and generic ROA pilot knowledge, skill and ability requirements. Analyses will include Mission, Function, and Task and Workload to identify high level requirements to enable the ROA pilot to comply with relevant, proposed, FAA ROA pilot and Air Vehicle Control Station (AVCS) certification criteria.

c. **Supporting the development of Pilot Rating Criteria for HALE ROA –** Results from Mission, Function and Information and Control analyses will be used to derive preliminary pilot rating criteria.

d. **ROA Functional Capability and Compliance** - Identifying functional areas where ROA capabilities cannot satisfy aircraft regulatory and air traffic control requirements.

e. **Simulation and Flight Test IPT Support** - Providing an input into the Simulation and Flight Test IPTs on the design of the AVCS, and on the

mission scenarios/test events that will be used to conduct these simulations/flight test activities.

f. **Air Traffic Control Analyses** - Performing analyses to the potential impact of ROA operations on ATC operator task requirements/workload. The goal is for the ROA system to be transparent to ATC. However, if it is determined that ATC operations will be impacted, then design guidelines will be developed to minimize the impact of ROA operations on the ATC system. Analyses may include Function, Information, and Control Analyses to identify the ability of the controller to comply with relevant, proposed, FAA requirements.

The results of these activities will be used to develop preliminary HSI design guidelines and AVCS functional requirements. As part of this process, the HSI IPT will develop comprehensive human factors requirements, and will provide guidance on methods for complying with proposed FAA requirements. The intent is not to develop a specific point design, but to develop generic, ROA guidelines that can be used by ROA manufacturers to obtain FAA approval for Experimental Certification. The information provided will also be of value to FAA personnel who are assigned the responsibility for AVCS certification. In addition, this effort will provide guidance to the Simulation and Flight Test IPTs in the form of specific HSI design recommendations to support simulation and test activities.

1.2 REPORT ORGANIZATION

This plan describes the tasks to be accomplished, the ACCESS 5 HSI IPT Organizational Structure, program interactions, and provides a schedule for Step 1 task accomplishment.

2 ORGANIZATION

2.1 ORGANIZATIONAL STRUCTURE

The ACCESS 5 organizational structure is shown in Figure 2-1. This IPT structure provides for a close interaction of HSI personnel with all other IPTs. HSI personnel will coordinate their activities with all other IPTs (i.e., Policy, ROA Impact, Technology, Simulation and Flight Test) to ensure that HSI considerations are included as required in the performance of these work packages and to minimize duplication of effort.

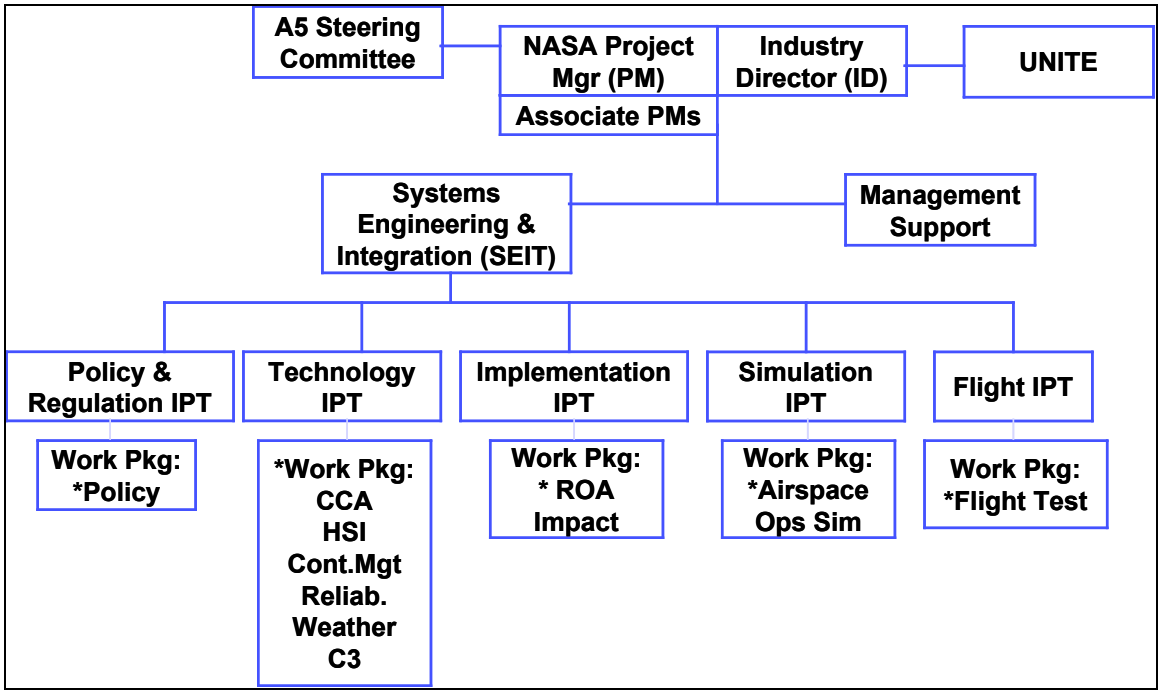

FIGURE 2-1: HSI ORGANIZATIONAL STRUCTURE

2.2 ACCESS 5 IPT RELATIONSHIPS

To ensure that HSI requirements are coordinated with the other IPTs, HSI personnel will accomplish the following activities:

a. Review all IPT work packages to determine what HSI inputs are required and to minimize duplication of effort

b. Participate in all major work package program reviews

c. Conduct Technical Interchange Meetings (TIMs) with other IPTs to facilitate coordination and work package deliverables.

2.3 ACCESS 5 HSI IPT KEY PERSONNEL

The following table provides a list of key HSI personnel, their affiliation, applicable experience and their roles on the HSI IPT.

TABLE 2-1: HSI PERSONNEL

NAM	COMPANY	APPLICABLE EXPERIENCE	ACCESS 5 ROLE
Sally Moore	The Boeing Company	20+ years human factors experience; pilot	HSI Work Package Lead
Gary Gershzohn	The Boeing Company	Airline pilot; air traffic controller; human performance expert; accident investigator	Human Factors support, and SME for ROA Pilot and ATC operations
Barry Berson	Lockheed Martin	30 + years of applicable Human Factors experience	Human Factors Support
Laura Boltz	Lockheed Martin	10+ years of applicable Human Factors experience	Human Factors Support
Ray McAdaragh	FAA/NASA	25 + years of applicable Human Factors experience	Human Factors Support
Mike Schultz	MTSI	15+ years Collision Avoidance and C3 experience/HSI	Cooperative Conflict Avoidance Technology
Ken Zugel	Aurora Flight Sciences	20+ years experience HALE ROA Pilot	ROA Pilot
Wayne Sadler	AeroVironment	10+ years experience HALE ROA Pilot	ROA Pilot sme
Bernie Schmidt	Northrop Grumman	20+ years pilot and systems engineering	ROA Pilot SME
Bob Blair	General Atomics	18+ years pilot, test pilot	Pilot SME
Richard Zanecki	General Atomics	20+ years pilot	ROA Pilot
Craig Bomben	NASA	20+ years pilot	Pilot

3 HUMAN SYSTEMS INTEGRATION IN SYSTEMS ANALYSIS

3.1 OVERVIEW

This section summarizes the analyses that ACCESS 5 HSI IPT personnel will perform to define AVCS pilot crew rating requirements, and to develop AVCS design guidelines and to assess the impact of HALE ROAs on ATC procedures and HSI design impacts. The results of these activities will support the development of Experimental Certification requirements for HALE ROAs.

3.2 TECHNICAL APPROACH

A description of the HSI analyses that will be performed to develop Experimental Certification Requirements and design guidelines for the integration of HALE ROAs into the NAS is contained in this section. This effort will focus on defining HSI requirements for the ROA pilot and air traffic controller. Requirements for Mission Planners, Sensor Operators, Maintainers, etc. are out of scope for this effort, and therefore will not be included in the Step 1 HSI Program Plan.

A series of Pilot and ATC controller reviews will be conducted to accomplish the work described in this section. The first Pilot review will concentrate on obtaining data to accomplish the mission and function analyses described in this section. Subsequent reviews will be conducted to perform the technology trade studies and to accomplish the Information and Control requirements analysis.

It is planned to conduct an ATC controller review to identify any potential HSI impacts resulting from the integration of HALE ROAs into the NAS. The objective of this review will be to identify potential impacts, and to obtain Subject Matter Expert (SME) opinions on how to reduce/eliminate any potential impact.

Figure 3-1 provides a Functional Flow Block Diagram of our approach for performing the required HSI analyses. This block diagram also illustrates the design tasks that are to be accomplished in Step 1. The design tasks are described in the next section. A brief description of our proposed analysis methodology is provided below.

3.2.1 IDENTIFY PRELIMINARY HSI REQUIREMENTS

This task consists of reviewing all relevant FAA documents that might impose requirements that would impact the certification of a HALE ROA AVCS. A preliminary list of relevant FAA Standards, Technical Orders, FARs is provided below.

- FAR Part 23/25
- FAR Part 91
- Aeronautical Information Manual
- FAA Order 7110.65P

- FAA Human Factors Design Standard

The output of this activity will be a detailed checklist. The checklist will contain sections that summarize all applicable requirements that relate to:

- Functions and tasks required of the pilot
- Functional requirements for ROA and AVCS hardware, software, and procedures
- Crew Rating requirements, and crew duty cycles
- Design of the AVCS HSI
- ATC Functions and Tasks
- Proposed regulatory requirements for ROA operations in the NAS (e.g., FARs)
- Proposed changes to FAA Order 7110.65
- Guidance on methods for manufacturer's compliance with proposed requirements

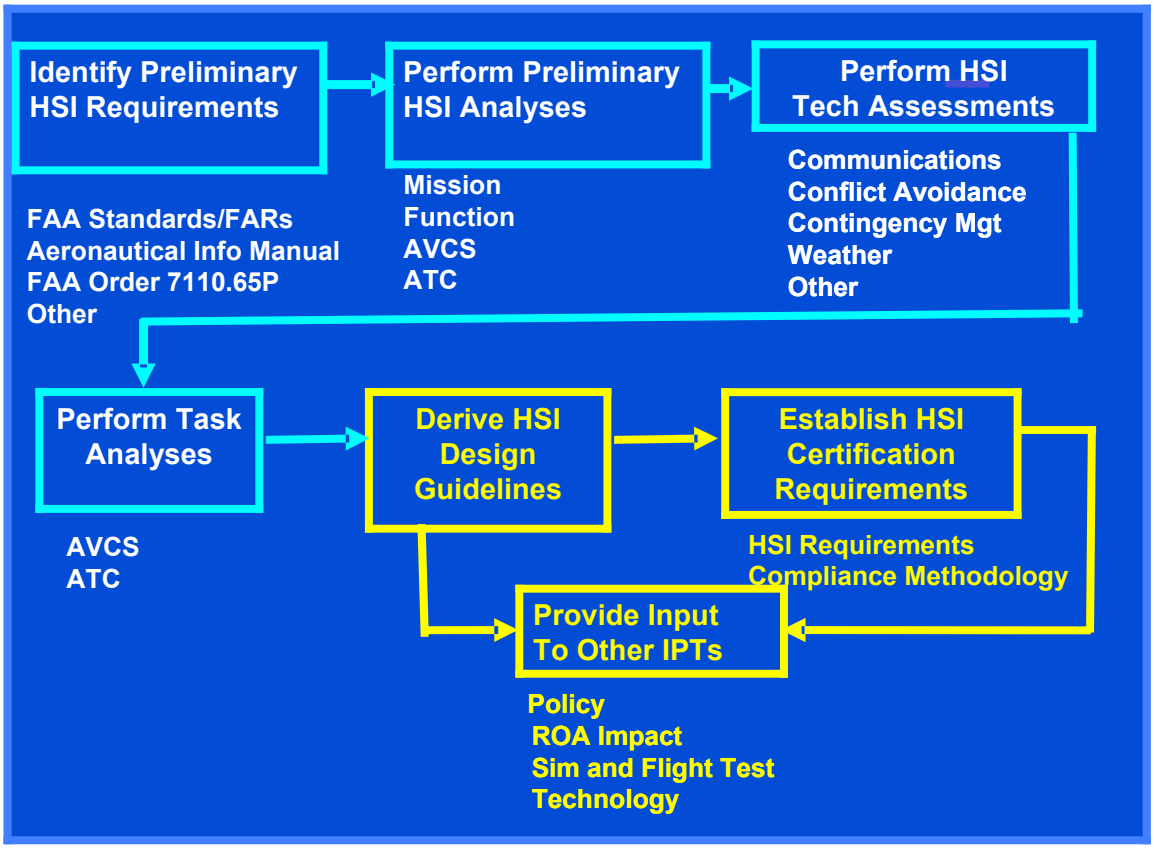

FIGURE 3-1: HSI ANALYSIS METHODOLOGY

3.2.2 PERFORM MISSION AND FUNCTION ANALYSES

3.2.2.1 Mission Analysis

This step consists of defining and decomposing a generic HALE ROA mission. To obtain this data, experienced ROA pilots and HSI personnel will work together to perform Mission and Function Analyses for ROA operations. The initial activity will concentrate on ROA operations above 40,000 feet. In subsequent Steps of the program, analyses will be conducted to concentrate on all other mission phases (Taxi, Takeoff, Climb, Cruise, Enroute operations above 18,000 feet, Approach and Landing). The data form provided in Appendix A will be used to collect the required data.

Missions will be decomposed to identify:

a. ***Mission Events.*** Significant nominal and contingency events relevant to operations at or above 40,000 feet.

b. ***Operator Tasks.*** Sequential list of all tasks that ROA pilot has to perform to accomplish mission objectives for flight at or above FL400.

c. ***Information Requirements.*** Preliminary listing of the information required by the pilots to accomplish identified tasks.

d. ***Control Requirements.*** Listing of the control requirements to accomplish each task.

3.2.2.2 Mission Decomposition

A mission profile will also be developed to provide a generic graphical representation of the vehicle's trajectory as a function of mission phase/segment. Mission segmentation consists of decomposing a mission into the major sequential activities that occur from the beginning to the end of the mission. At this stage of development, a three-level structure is being used to decompose the mission (i.e., Phases, Segments and Subsegments). These levels are defined as specific time periods within the mission which are grouped on the basis of homogeneity of operations. These levels have identifiable start and stop points (e.g., for the Takeoff Phase the start point is defined as the time when power is applied to the vehicle and ends when the vehicle lifts off the ground).

The purpose of dividing the mission into segments is to be able to analyze smaller, more convenient units of behavior. Mission decomposition includes:

a. Naming the mission phase/segment/subsegment

b. Defining the major roles and responsibilities for the pilots within each time period

c. Deriving start, stop and duration times for each mission phase, segment, and subsegment

A narrative summary of the major actions/events that occur within each mission time period will be developed to provide a representative structure for decomposing a generic HALE ROA missions. For Step 1, this analysis will be limited to the enroute portion of a flight (at or above FL 400).

3.2.2.3 Function Analysis

This activity consists of identifying the major functions that the vehicle systems and aircrew must perform to accomplish mission objectives. In effect, what the vehicle systems and operators have to accomplish during the mission define the major system functions (e.g., Flight Operations, Navigation, Communication, etc.).

These primary functions are then decomposed to identify:

a. ***Subfunctions*** (e.g., for the communication function, sub-functions include short, and long range communications, etc.).

b. ***Systems*** (e.g., the short range communication subfunction might include a V/UHF and Satellite communication systems, etc.).

c. ***System Functional Requirements*** (e.g., the UHF radio system includes; a transmitter, a receiver, associated antennas, system controls and indicators, etc.).

d. ***Preliminary Control and Information Requirements*** (e.g., to control a radio, control functions must enable the operator to turn the system on, to transmit and receive messages, etc. In addition, the system must provide specific information to enable the operator to use the system effectively (e.g., channel and frequency, current operational and available modes, system status, etc.).

This functional breakdown is required to identify the major tasks/jobs that the systems and pilot/ATC must perform to accomplish system objectives. At this stage of the analysis process, the functional breakdown is independent of the mechanisms used to accomplish a given function/task (i.e., whether a given function is allocated to a specific operator, to hardware/software, or to a combination of the two).

3.2.2.4 Function Allocation

In this step, the system functions are allocated to hardware/software, human operator, or to a combination of the above, based upon mission performance requirements, and on relative human and machine capabilities and limitations. Preliminary allocations will be based mainly on analysis results, and on the subjective perceptions of experienced operational, human factors and engineering personnel. These preliminary allocations will be refined based the results of simulation and flight-testing. Other allocation factors include; allocating functions based upon historical precedent (i.e., how functions are currently allocated on inhabited aircraft and ROAs) and relevant psychological literature describing human capabilities and limitations.

3.2.3 PERFORM HSI TECHNOLOGY ASSESSMENTS

In this step, work will be performed in support of simulation and flight test activities. To develop an AVCS for simulation purposes, trade studies will be accomplished to identify and evaluate current HSI procedures and control and

display interfaces used in current day HALE ROA AVCSs. The goal of this effort is to identify best practices for the integration of required technologies into the simulator AVCS. Based on test and evaluation results, this information will be used to develop preliminary HSI design guidelines. For Step 1, trade studies will be performed on communications (LOS and BLOS), Contingency Management, Cooperative Conflict Avoidance, and Weather Information systems.

To perform the trade studies, the following tasks will be accomplished:

- Identify Alternatives
- Develop Assessment Criteria (Quantitative and Qualitative)
- Weight Criteria, if applicable
- Identify Subject Matter Experts to perform the evaluations
- Tabulate results and identify high potential alternative(s)

The results of Mission, Function and Trade study analyses will be used to develop preliminary control and display guidelines for integrating these technologies into the simulator AVCS. This activity will include determining:

a. Information required by the ROA pilot to perform assigned tasks quickly and accurately. This includes the determination of cues, alerts, graphical and tabular information required to support task performance.

b. Determining controls required to support task execution. This will include determining the criticality, frequency and sequence of use of required control devices. This information will be used to provide recommendations/design guidance for arranging controls and displays within the simulator AVCS.

c. Develop preliminary concepts for the content and format of the Primary and Auxiliary Displays, including concepts for information coding (e.g., shape, color, line thickness and type, etc.) prioritization and display decluttering.

The results of the trade studies will be used to derive high potential HSI concepts that will be integrated into the AVCS that will be used to perform the Simulation IPT part-task and full mission simulations.

3.2.4 TASK AND WORKLOAD ANALYSIS

3.2.4.1 Task Analysis

Typically, in order to perform a task analysis, a preliminary workstation design is required. For this analysis, the results from the previous analyses and trade studies will be used to identify generic tasks that have to be performed by current day ROA pilots in the conduct of missions. For Step 1, this analysis will focus on tasks that are performed for the transit mission phases at or above 40,000 feet. Pilot SMEs, working on the HSI Work Package, and data obtained from simulation and flight test activities will be used to identify normal and contingency tasks for this mission phase as well as provide input into the assessment of the behavioral requirements for the tasks identified.

To support the development of AVCS Crew Rating requirements, the task analysis will identify and evaluate pilot skill, knowledge, and ability requirements. This preliminary task analysis will be performed to assess the:

a. Information presented to inform the AVCS pilot that a given task is to be performed,

b. Decisions the pilot has to make to perform a given task,

c. Controls and displays used by the pilot to accomplish a given task,

d. Specific control actions performed, and

e. Information provided (feedback) to enable the pilot to determine the adequacy of task performance. (In most cases, the feedback provided to the operator for performing one task becomes the indicator for performing the next task).

In addition, analyses will be conducted to determine the potential impact on ATC operations from the integration of ROAs into the NAS. To obtain this data, the HSI IPT will work closely with the ROA Impact and Simulation IPTs. In addition, data obtained from flight demonstrations will be used to support this analysis. If potential impacts are identified, the HSI IPT will perform requisite analysis to develop preliminary procedural, control and display concepts for minimizing the impact on ROA integration on controller workload, and to enhance SA. Promising concepts will be integrated into the Simulation IPT studies to assess their effectiveness.

The task analysis will provide data for:

a. Assessing the relative effectiveness of current function allocation schemes,

b. Identifying functional areas where ROA capabilities cannot satisfy aircraft regulatory and ATC requirements

c. Establishing standards and conventions to avoid potential HSI problems

d. Identifying Critical Tasks for more detailed analysis.

e. Establishing preliminary AVCS Pilot Rating requirements

3.2.4.2 Workload Analysis

To assess workload, two metrics will be derived (1) Activity Level, and (2) Task Difficulty. Where Activity Level is defined as the ratio of the time required to accomplish given tasks divided by the time available for task accomplishment. To assess Task Difficulty, the McCracken-Aldridge Workload Scales will be used. Separate scales are provided to assess the auditory, visual, cognitive and psychomotor resource demands of crew allocated tasks. Seven-point anchored rating scales are provided for each scale. On these scales, a 1 is used to indicate very low task demands, and a 7 is used to indicate very high or excessive demands. Figure 3-2 shows the McCracken-Aldridge scale for Cognition.

TABLE 3-1: MCCRACKEN-ALDRIDGE COGNITIVE WORKLOAD SCALE

Scale Value	Descriptor
1.0	Automatic (Simple Association)
1.2	Alternative Selection
3.7	Sign/Signal Recognition
4.6	Evaluation / Judgment (Simple)
5.3	Evaluation / Decoding (Recall)
6.8	Evaluation / Judgment (Complex)
7.0	Estimation, Calculation or Conversion

To support the identification of high workload time periods within the mission, multiple criteria will be used (e.g., mission time period where an operator has an average Activity Level of 80 % or greater, and average task demands, for any one resource greater than 5.5 on the McCracken-Aldridge Scales).

Workload analysis results will provide data for identifying:

a. Mission "Choke-points" (Mission time periods where operators experience excessively high workload levels, (i.e., activity levels greater than 80%, or resource demand levels greater than 5 on any resource dimension));

b. Operator task overload, either due to excessive Activity Levels or Task Demands; and

c. Candidate tasks for redesign of the simulator AVCS. Options for redesign include:

   (1) Simplifying the design of the controls and displays used to accomplish the task,

(2) Automating the task or providing a decision aid to facilitate task execution, or
(3) Reallocating the task to a "less busy"/ “less stressed” operator.

4 HUMAN SYSTEMS INTEGRATION IN DESIGN

4.1 OVERVIEW

This section summarizes the major design activities that will be accomplished in Step 1 to support the development of Experimental Certification Requirements, and preliminary AVCS and ATC guidelines.

4.2 HSI DESIGN ACTIVITIES

HSI personnel will perform the following tasks to achieve the objectives specified above:

4.2.1 DEVELOP PRELIMINARY HSI DESIGN GUIDELINES

This task will generate a set of preliminary HSI design guidelines that will be used to support the development of the AVCS that will be used to conduct the part task and full mission simulations.

To develop these design guidelines the following activities will be performed.

a. **Literature Review** - Reviewing applicable FAA standards, FARs, FAA Order 7110.65P, and guidance provided in the Aeronautical Information Manual, etc. to support the development of AVCS design and pilot/operator skill, ability and knowledge requirements; and the impact on air traffic control. Starting with the FAA Human Factors Design Standard (DOT/FAA/CT-96/1, design guidance from Human Factors specifications and standards (e.g., MIL-STD-1472, JSSG 2010, etc.), and from Graphic User Interface (GUI) standards, and previous design guidelines (e.g., Unmanned Aerial Vehicles Human Factors Guidelines (Richardson and Gibson, 1998), etc.) will all be reviewed and integrated into our preliminary Step 1 HSI Design Guide.

b. **Supporting the development of Pilot Rating Criteria for HALE ROA –** Results from analyses and reviews with subject matter experts will be used to derive preliminary Pilot rating criteria

c. **ROA Functional Capability and Compliance** - Identifying functional areas where ROA capabilities cannot satisfy aircraft regulatory and air traffic control requirements.

d. **Simulation and Flight Test IPT Support** - Providing an input into the Simulation and Flight Test IPTs on the design of the AVCS-that will be used to perform part-task, full-mission simulations, and flight tests, and on the mission scenarios/test events that will be used to conduct these simulations/flight test activities.

e. **Site Visits** – Conducting site visits and interviewing ROA pilots to identify what they like/do not like about current day AVCSs. Obtain lessons learned data on problems/difficulties experienced in present day operations.

f. **Mishap/Accident Data Review**- Reviewing mishap/accident data to determine whether the ROA pilot, or the design of the AVCS was listed as a contributing factor in ROA/UAV accidents.

g. **Simulation and Flight Test** - Supporting Simulation and Flight Test activities to observe AVCS operations, and to obtain objective and subjective ROA pilot and ATC Controller performance and subjective preference data.

Topics to be included in the HSI Design Guide will include:

- Visual displays – Analog, digital, qualitative, pictorial and symbolic, static and dynamic graphics
- Auditory displays – Verbal and non–verbal
- Integrated Caution and Warning Systems – Visual and auditory components
- Kinesthetic and tactile displays – Determining control position and load through amount of movement and resistance
- Controls – Rotary (knobs, cranks, wheels), linear (levers, push–buttons, pedals, handles), and special purpose (remote handlers, manipulators)
- Specialized input devices – Keyboards, and computer interfaces
- Control–display dynamics – Movement ratios, compatibility, aided controls, quickened displays
- Physical environmental factors affecting human performance – Lighting, noise, vibration, motion, atmospheric composition and pressure, and temperature
- Workspace layout – Limits of working area, physical and visual access, orientation, location and arrangement of components

4.2.2 ESTABLISH HSI EXPERIMENTAL CERTIFICATION BASIS AND COMPLIANCE METHODOLOGY

This activity will focus on developing preliminary human factors requirements, derived from FARs and other FAA documentation, to provide a certification basis for obtaining an Experimental Certification, and will describe methods of compliance for verifying preliminary requirements. The FAAs Policy Statement Number ANM-99-2 (Requirements for Reviewing Certification Plans to Address Human Factors for Certification of transport Airplane Flight Decks) will be tailored to derive preliminary certification and compliance methods for the AVCS. The content and format of this document is described in the Deliverables section of this report.

5 HUMAN SYSTEMS INTEGRATION IN THE DERIVATION OF PILOT RATING REQUIREMENTS

5.1 OVERVIEW

HSI IPT personnel will play a major role in the development of proposed pilot rating criteria. (Maintainer requirements may be addressed in subsequent steps of the ACCESS 5 program.) Specifically, information contained in the Task Analyses will indicate the decisions that these personnel will be required to make to accomplish assigned tasks. Identification of these decision-making requirements (i.e., what information the pilot needs and what decisions he/she has to make) provides essential information for determining skill, knowledge and ability requirements.

As indicated above, pilot-rating requirements will be derived from the results of HE analysis, design and evaluation activities. Task and workload analyses will be conducted to define and evaluate generic operator information, control and display requirements to monitor and control ROAs in the NAS for mission operations at or above FL 400. In addition, the results of Simulation and Flight Test evaluations will be used to update and refine the analysis data.

6 HUMAN SYSTEMS INTEGRATION IN TEST AND EVALUATION

6.1 OVERVIEW

HSI personnel will perform detailed evaluations to support the development of HALE ROA HSI requirements. Part task, full mission and flight test evaluations will be conducted. The HSI test program will be integrated within the overall Simulation and Flight Test IPT programs to ensure completeness of the data collection activities and to minimize duplication. Figure 6-1 summarizes the major HSI study areas, describes the purpose of each evaluation, how the evaluation is to be accomplished and applicable performance measures.

TABLE 6-1: MAJOR HSI STUDY AREAS FOR TEST AND EVALUATION

STUDY AREA	OBJECTIVES	ISSUES	METHODS	PERFORMANCE MEASURES
1. AVCS Functional Design Capability and Operability	Functional Design Compliance to applicable FARs/Design Standards Workload Management and SA	• Information availability • Control Capabilities • Operability, Workload and SA	• Analyses • Part Task and Full Mission Simulation • Flight Test Evaluations	• Compliance with applicable FAA/HSI Standards and Specifications • Empirical Performance and Subjective Opinion Data
2. ATC Procedures/	Minimize Impact of ROA operations on ATC/NAS	• ATC Workload and SA	• ATC Procedural/ Documentation Review • Analyses • Specification Compliance Checklists • Part Task and Full Mission Simulation • Flight Test Evaluations	• Compliance with applicable FAA/HSI Standards and Specifications • Empirical Performance and Subjective Opinion Data
3 ROA Pilot Controls and Displays	Develop Requirements and Design Guidelines	• Control and Display design based on HSI Analysis, Design & Test Results • Effective use of Multicolor displays and integrated controls. • Ease of use • Reduce Workload, Personnel and Training Requirements.	• Design Checklists • Subjective Opinion Surveys • Derivation of Information Display and Control Requirements • Mockup Evaluations/ Operator Surveys • Ground and Test Evaluations	• Empirical system and Aircrew/Maintainer Performance Times • Subjective and Empirical data on Aircrew/Maintainer Performance and Workload Levels

STUDY AREA	OBJECTIVES	ISSUES	METHODS	PERFORMANCE MEASURES
4 Pilot Rating Criteria	Develop preliminary Pilot Rating Criteria	• Pilot skill, knowledge and ability requirements • Physical Capabilities/ Limitations • Preliminary Training Requirements	• HSI Analyses • Subjective Opinion Surveys • Part and Full Mission Simulations and Flight Test Evaluations	• Subjective and Empirical data on Aircrew/Maintainer Performance and Workload Levels

6.2 HUMAN SYSTEMS INTEGRATION EVALUATION ACTIVITIES

6.2.1 PART TASK AND FULL MISSION SIMULATION

Part task and full mission evaluations will be performed to support the development of requirements, design guidelines and to assess the utility of selected HSI concepts on AVCS pilot and ATC performance. HSI personnel will develop and administer questionnaires to obtain ROA pilot and air traffic controller preference data. In addition, objective performance data (time to complete specified tasks, errors made, etc,) will be obtained. These evaluations will also assess promising HSI concepts for integrating key Step 1 technologies (Communications, Contingency Management, Cooperative Conflict Avoidance, Weather information, etc.). Again, the goal here is to develop requirements/ design guidelines, and not to develop a point design to be imposed on ROA manufacturers.

Specific areas to be addressed in the HSI test and evaluation effort will include:

a. **ROA Pilot Functions and Tasks** – Obtain data to support the development of Pilot skill, knowledge and ability requirements

b. **AVCS Control and Display Designs**. Issues to be addressed will include:

   1. Information interfaces and aircrew station signals, including symbol and character sizes, information density and readability, understandability of symbology, spatial orientation, etc., will be addressed to support requirements derivation and to support the development of design guidelines
   2. Aircraft system control and data entry. This includes determining effective concepts that will enable the ACVS Pilot and ATC operator to interact with their systems to reduce workload and facilitate SA and safety.
   3. Performing assessments to verify that AVCS HIS functional designs satisfy aircraft regulatory and ATC requirements

c. **Workload.** Results of these evaluations will be used to determine whether additional design refinements (HSI design simplification, function

automation, requirements for decision aiding, reallocating task to the other operator, etc.) are required to reduce operator workload levels.

d. **AVCS New Technology Integration.** The assessment of the impact of new technology integration on operator performance and mission effectiveness will be included in the control-display and workload evaluations described above. Full consideration will be given to assessing the impact of new technologies on pilot skill, knowledge and ability requirements.

e. **Air Traffic Control**. Test and evaluation will be performed to assess the impact or ROA operations on ATC controller workload and SA.

6.2.2 FLIGHT TEST EVALUATIONS

The HSI activities performed in support of Flight Test evaluations will provide data that will support the definition of Pilot KSAs. In support of these objectives, HSI personnel will support the following T&E activities:

HSI personnel will develop and administer questionnaires to obtain ROA pilot and ATC operator preference data. In addition, objective performance data (time to complete specified tasks, errors made, etc,) will be obtained to support the assessment of significant ROA pilot, AVCS, and ATC issues. These may include topics such as:

1. Adequacy of the design and operability of the controls and displays. This also includes assessing concepts for function automation, adaptive systems and for decision aids, as well as assessing the utility of new technology integration,
2. Acceptability of workload levels and SA
3. Potential impact of ROA operations on ATC controllers and on the NAS

The results of all of these activities will be documented in the applicable ACCESS 5 Test Reports. HSI design deficiencies and problem sheets will be documented and discussed with ACCESS 5 personnel to derive solutions to identified problems.

7 HUMAN SYSTEMS INTEGRATION DELIVERABLE DATA PRODUCTS, SCHEDULE AND MANPOWER REQUIREMENTS

7.1 HSI DATA PRODUCTS

The following documents will be provided to summarize the procedures employed and the results obtained from the HSI IPT analyses, design and test and evaluation activities accomplished during Step 1. Deliverables for 2004 through 2006 are provided below.

7.1.1 2004 HSI DELIVERABLES

a. **Step 1 HSI Program Plan.** This plan briefly describes the tasks that are to be accomplished by the HSI IPT in support of the ACCESS 5 program for the current step. It is planned to update the HSIPP at the beginning of each step.

b. **Preliminary HSI Concept Requirements Definition**. This preliminary report will serve as a repository for all information obtained in 2004 relating to the interface between the ROA pilot and ATC. Information from scheduled workshops, literature reviews, and observations from the Alaska Flight Test program will be used to generate the information contained in this report.

c. **Preliminary HSI Design Guide**. This preliminary report will serve as the repository for all HSI developed, FAA approved requirements, guidelines and procedures as applied to the HSI aspects of the ACCESS 5 program.

7.1.2 2005 HSI DELIVERABLES

a. **Initial HSI Functional Requirements for ROA Flight in the NAS (9/05).** This activity consists of identifying the major functions that the ROA vehicle systems and aircrew must perform to accomplish mission objectives. The report will identify primary functions and decomposed elements in the following categories: Crew Subfunctions, System Functional Requirements, and Preliminary Control and Information Requirements.

b. **Initial HSI Requirements and Guidelines for Experimental Certification (Draft - 3/05 Step 1 Final - 9/05).** This document will provide requirements for the certification of a ROA AVCS. This document will describe methodologies that can be used to achieve AVCS certification. This report will also describe certification criteria, issues and validation concepts. It is planned to update this report at the end of each step.

c. **Initial HSI Requirements for Pilot Rating (Draft 3/05, Final 9/05).** This report will describe the results of analyses and trade studies that are to be completed to support the development of ROA Pilot Rating Criteria. The focus of this report will be on defining Pilot KSAs. The policy IPT will then use this information to develop recommendations for Pilot rating requirements.

d. **Initial HSI Support for CCA, C3, CM, and Weather Technology Development (3/05; 9/05).** This report will specify preliminary HSI requirements and design guideline information for identified technologies that support ROA flight in the NAS. The report will contain a literature review identifying HSI recommendations for program and HSI-identified technologies. Analytic, simulation, and flight test results will be documented as part of a process to downselect options for HSI technology interface requirements for the ROA system.

e. **Initial HSI Support for Simulation and Flight Test and Evaluation for CCA, C3, CM, and Weather (3/05; 9/05; other date(s) as required by test planning IPT).** This report will specify preliminary requirements and design guideline information for support of simulation and flight test activities. Experiment objectives, methodologies, HSI data collection devices, and statistical results sections for each simulation or flight test study will be provided as part of the overall test plan document. As needed, the report also will contain mission scenarios and events to be included in the evaluations.

7.1.3 2006 HSI DELIVERABLES –

a. **Updated HSI Functional Requirements for ROA Flight in the NAS** (**9/06**). This activity consists of identifying the major functions that the ROA vehicle systems and aircrew must perform to accomplish mission objectives. The report will identify primary functions and decomposed elements in the following categories: Crew Subfunctions, System Functional Requirements, and Preliminary Crew Control and Information Requirements.

b. **Updated HSI Requirements and Guidelines for Experimental Certification (9/06).** This document will provide updated requirements for the design, development and certification of ROA AVCS. The report will focus on developing design guidelines for the interface between the ROA pilot and ATC, and between the pilot and the ROA. This document also describes methodologies that can be used to achieve AVCS certification. This report will also describe certification criteria, issues and validation concepts. It is also planned to update this report at the end of each step.

c. **Updated ROA Pilot Knowledge, Skill and Abilities (KSA) Updated for Medical and Training Requirements (2/06).** This report will update the results of analyses and trade studies that are to be completed to support the development of ROA Pilot/Operator Crew Rating Criteria. This will include defining minimum qualifications for these pilots (experience, education, training, etc.) and the number of pilots required to operate an ROA.

d. **HSI Requirements for ATC Integration with ROAs (2/06).** This report will update results of analytic evaluations that define the impact on air traffic controller human interfaces of potential ROA operations. It will include descriptions of FAA Order 7110.65, air traffic controller functions, tasks, information and control requirements, and workload that will be issues for ROA operation.

e. **Updated HSI Support for CCA, C3, CM, and Weather Technology Development (2/06; 9/06).** This report will specify preliminary HSI requirements and design guideline information for identified technologies that support ROA flight in the NAS. The report will contain a literature review identifying HSI recommendations for program and HSI-identified technologies. Analytic, simulation, and flight test results will be documented as part of a process to downselect options for HSI technology interface requirements for the ROA system.

f. **Updated HSI Support for Simulation and Flight Test and Evaluation for CCA, C3, CM, and Weather (2/06; 9/06).** This report will specify preliminary requirements and design guideline information for support of simulation and flight test activities. Experiment objectives, methodologies, HSI data collection devices, and statistical results sections for each simulation or flight test study will be provided as part of the overall test plan document. As needed, the report also will contain mission scenarios and events to be included in the evaluations.

7.2 HSI SCHEDULE

Figure 7-1 presents overall program schedule for the accomplishment of required Step 1 HSI analysis, design and T&E activities.

HSI Deliverable	FY04 Date	FY05 Date	FY06 Date
Step 1 HSI Program Plan	6/04		
Preliminary HSI Concept Requirements Definition	9/04		
Preliminary HSI Design Guide	9/04		
2005			
Initial HSI Functional Requirements for ROA Flight in the NAS		9/05	
Initial HSI Requirements and Guidelines for Experimental Certification		3/05; 9/05	
Initial HSI Requirements for Pilot Rating		3/05; 9/05	
Initial HSI Support for CCA, C3, CM, and Weather		3/05; 9/05	

HSI Deliverable	FY04 Date	FY05 Date	FY06 Date
Technology Development			
Initial HSI Support for Simulation and Flight Test and Evaluation for CCA, C3, CM, and Weather		3/03; 9/05; other date(s) as required by test planning IPT	
2006			
Updated HSI Functional Requirements for ROA Flight in the NAS			9/06
Updated HSI Requirements and Guidelines for Experimental Certification			9/06
ROA Pilot Knowledge, Skill and Abilities (KSA) updated for medical and training requirements			2/06
Updated HSI Requirements for ATC Integration with ROAs			2/06
Updated HSI Support for CCA, C3, CM, and Weather Technology Development			2/06; 9/06
Updated HSI Support for Simulation and Flight Test and Evaluation for CCA, C3, CM, and Weather			3/06; 9/06; other date(s) as required by test planning IPT

FIGURE 7-1: Schedule for the HSI Work Package for Step 1

Appendix A

HUMAN SYSTEMS INTEGRATION (HSI)
MISSION AND FUNCTION ANALYSIS DATA FORMS
MAY, 2004

Mission Analysis

Please provide a narrative description of a representative flight of a UAV system with which you have the most experience. Describe the purpose of the flight. Provide a horizontal profile (e.g., footprint) and a vertical profile timeline showing numerous events. Briefing describe the most significant events for taxi out, departure, approach and landing; provide more detail for enroute portion of the flight – above FL400. After describing flight events, please identify what you consider to be the issues relative to this mission (e.g., speed, endurance, crew complement factors, and weather avoidance) that would have an impact on operation in the National Airspace System?

Function Analysis

Instructions: Please review the following list of air vehicle functions. Check the functions that you consider necessary to operate the UAV in a file and fly system in order to perform the intended flight described in the mission analysis. If a particular function is not available describe the expected impact to operations.

ID	**Functionality Description**	Functional Capability	
FLIGHT[1]			
	PITCH/ROLL/YAW		
	TRUE AIRSPEED		
	GROUND SPEED		
	INDICATED/EQUIVALENT AIRSPEED		
	MACH		
	ALTITUDE		
	BAROMETRIC SETTING		
	HEIGHT ABOVE GROUND		
	VERTICAL SPEED		
	FLIGHT PATH ANGLE		
	BANK ANGLE LIMIT		
COMMUNICATIONS			
	OPERATOR-ATC COMMUNICATIONS		
	OPERATOR-UAV COMMUNICATIONS		

[1] CONTROL AND/OR DISPLAY

	OPERATOR-VHF/UHF COMMUNICATIONS		
	UAV-ATC COMMUNICATIONS		
	NAVIGATION[1]		
	HEADING		
	HEADING INTENT[2]		
	TRACK (MAG/TRUE)		
	TRACK INTENT (MAG/TRUE) [2]		
	VERTICAL PROFILE GUIDANCE		
	VERTICAL PROFILE DEVIATION		
	LATERAL PROFILE GUIDANCE		
	LATERAL PROFILE DEVIATION		
	TRUE AIRSPEED INTENT[2]		
	GROUND SPEED INTENT[2]		
	INDICATED/EQUIVALENT AIRSPEED INTENT[2]		
	MACH INTENT[2]		
	ALTITUDE INTENT[2]		
	VERTICAL SPEED INTENT[2]		
	INTERACTIVE FLIGHT PLAN REVISING		
	FLIGHT PATH ANGLE INTENT[2]		
	RNAV		
	RADIO (VHF/UHF)		
	DME DISTANCE		
	PRECISION APPROACH		
	NON-PRECISION APPROACH		
	AUTOMATIC DIRECTION FINDING (VHF/UHF)		
	MARKER BEACON IDENTIFICATION		
	GNSS (ENROUTE)		
	FANS		
	DISTANCE TO GO		
	TIME TO GO		
	WIND SPEED AND DIRECTION		

[2] INTENT INFORMATION REQUIRED BY SOME FUTURE CNS/ATM CONCEPTS

	ETA AT WAYPOINT		
	ACTUAL NAVIGATION PERFORMANCE/ REQUIRED NAVIGATION PERFORMANCE		
	AIRCRAFT POSITION		
	NAVIGATION PERFORMANCE PREDICTION		
	GROUND MAPPING RADAR		
	IDENTIFY GROUND TRAFFIC (DIRECT VIEW)[3]		
	IDENTIFY GROUND TRAFFIC (ELECTRONIC)[4]		
	FOLLOW GROUND TRAFFIC (DIRECT VIEW)		
	FOLLOW GROUND TRAFFIC (ELECTRONIC)		
	IDENTIFY HOLD LINES		
	IDENTIFY IN FLIGHT TRAFFIC (DIRECT VIEW)		
	IDENTIFY IN FLIGHT TRAFFIC (ELECTRONIC)		
	FOLLOW IN FLIGHT TRAFFIC (DIRECT VIEW)		
	FOLLOW IN FLIGHT TRAFFIC (ELECTRONIC)		
SURVEILLANCE			
	PERMIT ATC SSR PARAMETER IDENTIFICATION		
HAZARD AVOIDANCE – SURVEILLANCE[3]			
	WEATHER (DIRECT VIEW)		
	WEATHER (RADAR)		
	PRECIPITATION (DIRECT VIEW)		
	PRECIPITATION (ELECTRONIC)		

[3] DIRECT VIEW = VISUAL OBSERVATION AND/OR VIDEO PICTURE OF TRAFFIC
[4] ELECTRONIC = DATA DISPLAYED TO OPERATOR THAT PROVIDE POSITION INFORMATION

	TURBULENCE (DIRECT VIEW)		
	TURBULENCE (ELECTRONIC)		
	LIGHTNING (DIRECT VIEW)		
	LIGHTNING (ELECTRONIC)		
	VOLCANIC ASH (DIRECT VIEW)		
	WINDSHEAR		
	TERRAIN (DIRECT VIEW)		
	TERRAIN (ELECTRONIC)		
	TRAFFIC – GROUND (DIRECT VIEW)		
	TRAFFIC – GROUND [ELECTRONIC (XPONDER; DL)		
	TRAFFIC – IN FLIGHT (DIRECT VIEW)		
	TRAFFIC – IN FLIGHT (ELECTRONIC)		
	DISPLAY OF TRAFFIC INFORMATION		
	FORMATION FLIGHT		
	INSPECT/CLEAR TAXIWAY/RUNWAY		
	INSPECT/CLEAR AREA PRIOR TO DEPARTURE		
	INSPECT/CLEAR PRIOR TO ARRIVAL		
HAZARD AVOIDANCE – VEHICLE SYSTEMS[5]			
	STRUCTURAL ICING avoidance		
	ENGINE ICING		
	IMAGING SYSTEM ICING/FOGGING		
	EXTENDED ELECTRICAL POWER DURATION		
MISCELLANEOUS			
	IDENTIFY VFR CONDITIONS		
	What about Health and Status Information, access to BIT, Sensor/system controls, etc.?		

Information Requirements

What information do you not have that he would like to have for the flight described in mission analysis? What does limitation of this information mean for complying with

[5] EQUIVALENCY TO CURRENT VEHICLES

ATC instructions and other operational limitations? Please list and give examples as possible. Again, might be worthwhile to provide structure- Break out by specific phases/tasks. What tasks are the hardest? Why are they difficult? What can be done to reduce difficulty?

Lessons-Learned

What are some of the major hurdles that have to be overcome? What workstation HSI deficiencies do you presently have that impacts workload or situation awareness (SA), e.g., what additional info should be provided, how could controls be redesigned, more automation, better awareness of what automation is doing, ergonomic concerns, etc.? What can be done to reduce workload/enhance SA? Again, probably better to provide more structure - For example!

- HSI deficiencies (Controls and Displays) - Please list the top 5/10 deficiencies in your current work station. This includes the adequacy of information provided, the adequacy of control operations, etc.

- Automation Concerns - Please any deficiencies in current automation schemes. If you identify any concerns what can be done to improve operability (e.g., better feedback on state of automation, intent of automation, automation failures, etc.)

- HSI Ergonomic Deficiencies - Please list any workstation or environment concerns that could impact performance, or operator comfort/safety.